RESEARCH AND GUIDANCE FROM HSE

Ignitability of diesel fuel mists over a vertical distance

Louise O'Sullivan BSc Hons, MRSC

HAZ31_066

Research - HSE funded to provide evidence which underpins its policy and regulatory activities
Guidance - freely available to help people comply with health and safety law

Introduction

- In the UK, the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) require employers and duty holders to classify areas into zones where fire and explosion hazards may occur.
- However, guidance for high flashpoint fluid mists is relatively sparse.
- Combustible fluids formed into an aerosol of fine droplets can create a flammable atmosphere that can be ignited, even at temperatures below the fuel's flash point.
- Such aerosol mists can be formed by, for example, pressurised leaks from damage of pipelines used to transfer or deliver fuel to machinery. Leaks are commonly caused by material corrosion, fatigue crack mechanisms or inadequate sealing of fittings

Introduction MISTS 2 Aims

This project, MISTS2, focused on situations where empirical results can be used to give the greatest improvement in understanding of mist explosion safety. It had three work packages (WP1 to WP3) whose aims were to:

- Directly assess whether diesel fuel, one of the most widely used fluids that could form a flammable mist, shows the same unexpected ease of ignition seen with Kerosene in the MISTS work (WP1);
- Assess the effect of different leak paths on the ignitability of the mist formed (WP2);
- Directly assess the maximum distance that a leak can travel before it has dissipated to the point it cannot be ignited (WP3).

The work covered in this presentation was undertaken in work package 3: the assessment of the maximum distance at which a leak remains ignitable.

Aims of Vertical ignition tests

The MISTS2 project aims to provide experimental data on the formation and ignitability of diesel mists. It is anticipated that this data, along with data previously gathered in the project MISTS, will be used to validate and further the understanding of area classification, and to update guidance in the area of high flashpoint mist hazards.

The aim(s) of this experimental package (WP3) within the MISTS2 project are:

- To create a vertically oriented diesel mist over a test distance of up to 8 metres.
- To establish the furthest ignitable distance in this diesel mist.
- To test the extent of the flammable mist at the lowest release pressure at which ignitions readily occur, between 5 and 20 bar gauge.
- To observe the flame progression and consequences of ignition at various locations within the diesel mist.

Methods

- To undertake the flammability trial a vertical mist jet of diesel mist was required.
- A pressurised release of diesel was created with a long jet length of 8 meters.
- The release was undertaken indoors. This facility is a realistic environment for a mist release indoors and provided shelter from weather effects.
- The burn hall facility allowed for the installation of a 10-meter-tall scaffold tower with an 8-meter-high release point

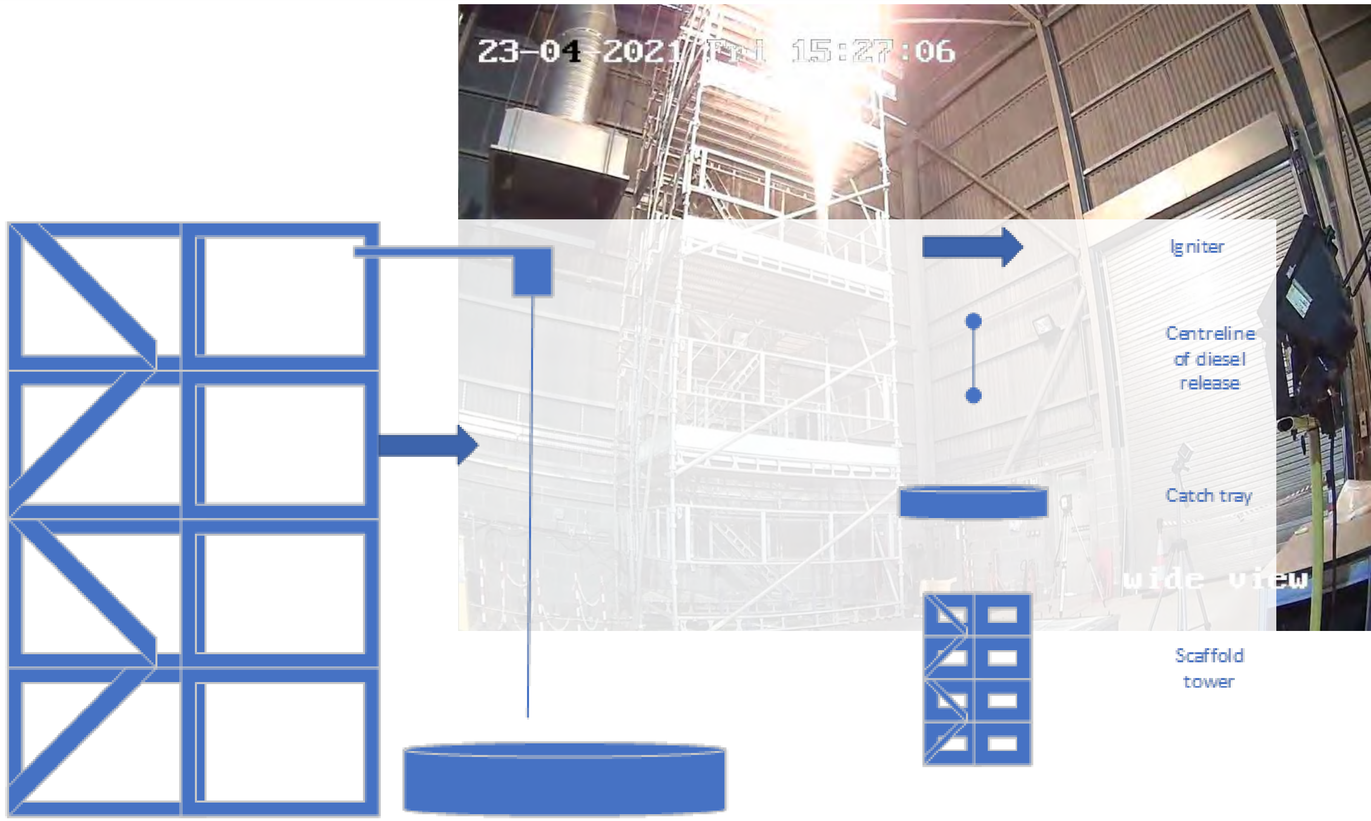


Figure 02: Scaffold Test outline

Methods

- The test orientation, gives the axial distance in meters (m) as the distance vertically between the release point and the ignition point. The radial distance in meters (m) is the distance horizontally from the centreline of the nozzle mist release.

Figure 04: release nozzle α 1mm

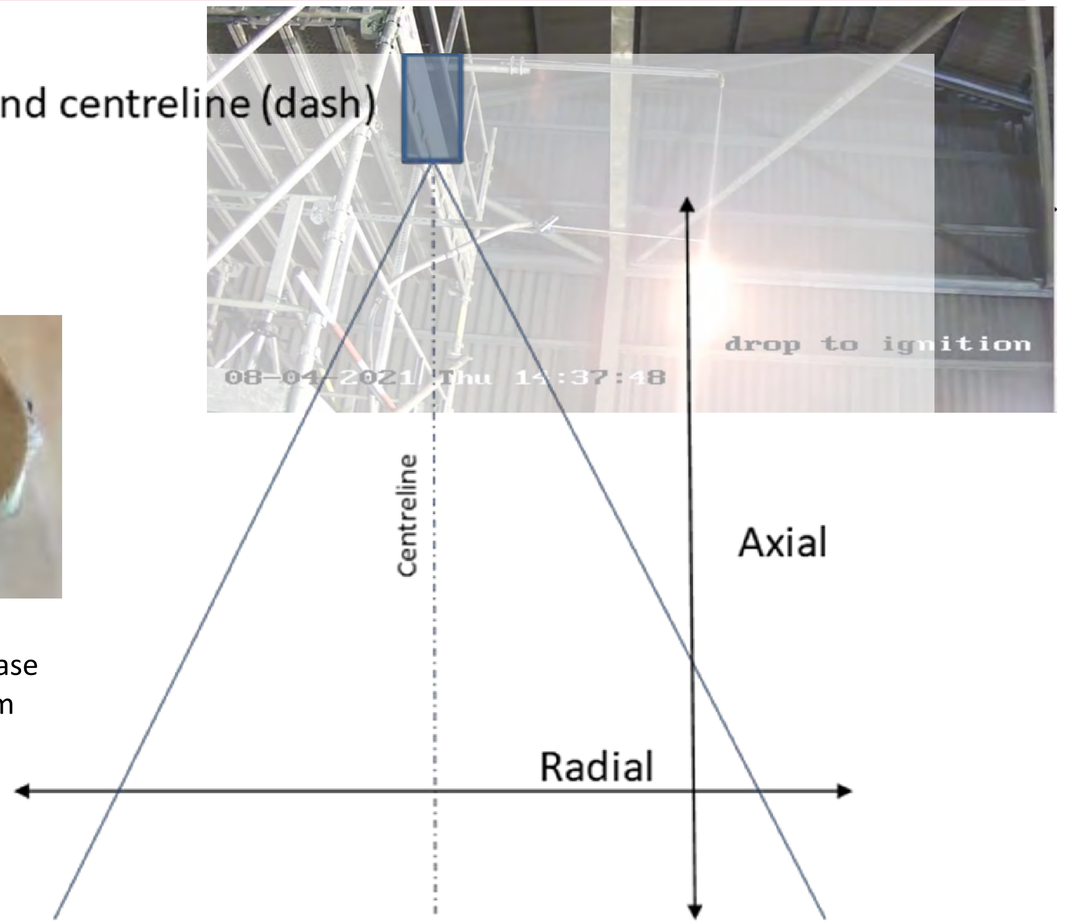
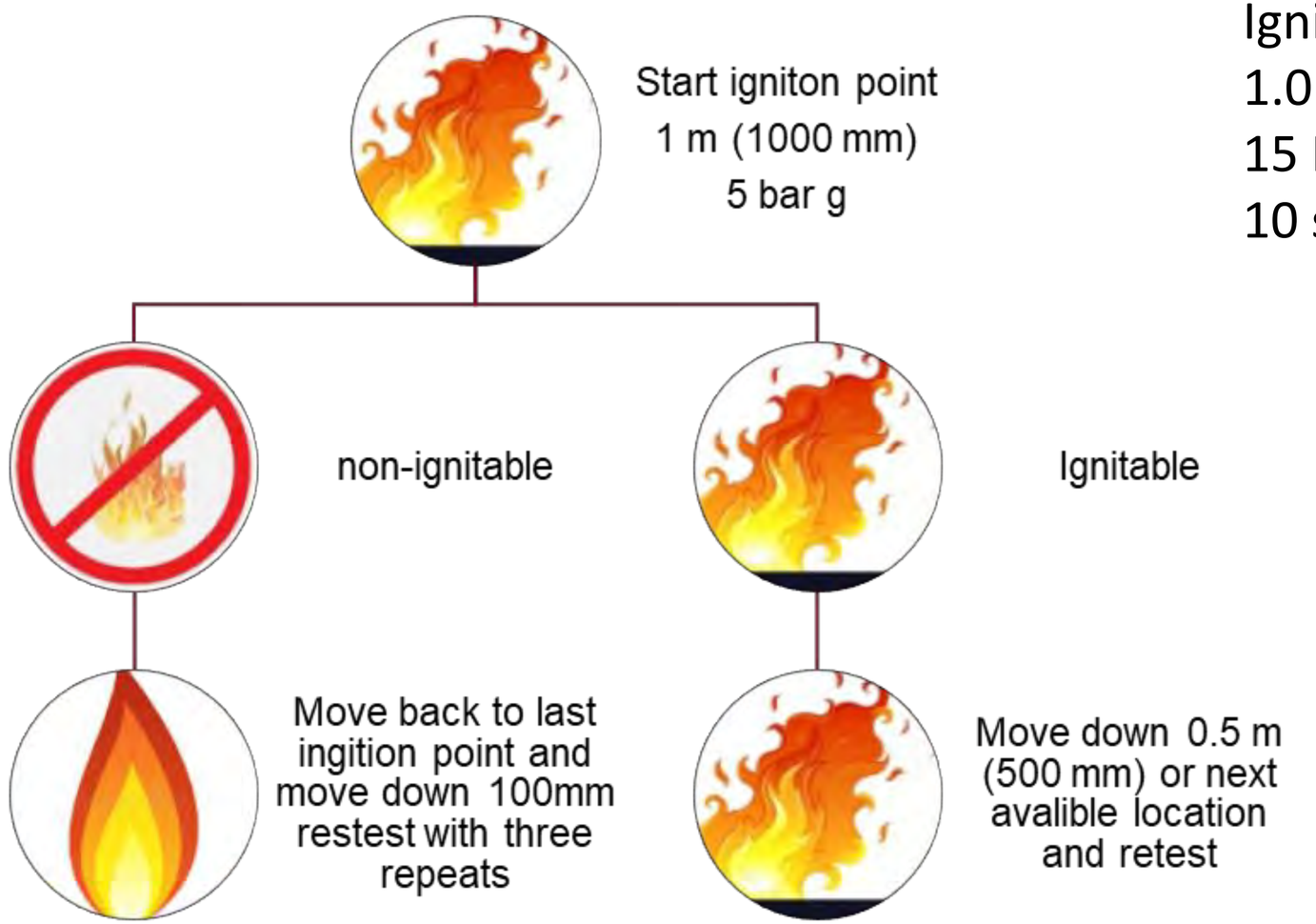


Figure 03: Release orientation schematic

Test method



Igniter Type:
1.0 J
15 HZ repetition
10 seconds release

Figure 05: Test methodology for 5 bar tests

RESEARCH AND GUIDANCE FROM HSE

RESULTS

Results

- Ignitions of the mist stream were seen at:
  - Axial distances from 1.0 m to 4.75 m.
  - Radial distances of up to 0.30 m at 1.0 m axially.
  - Radial distances of up to 0.12 m at 2.9 m axially.

- Alignment of the igniter into the mist stream was important.

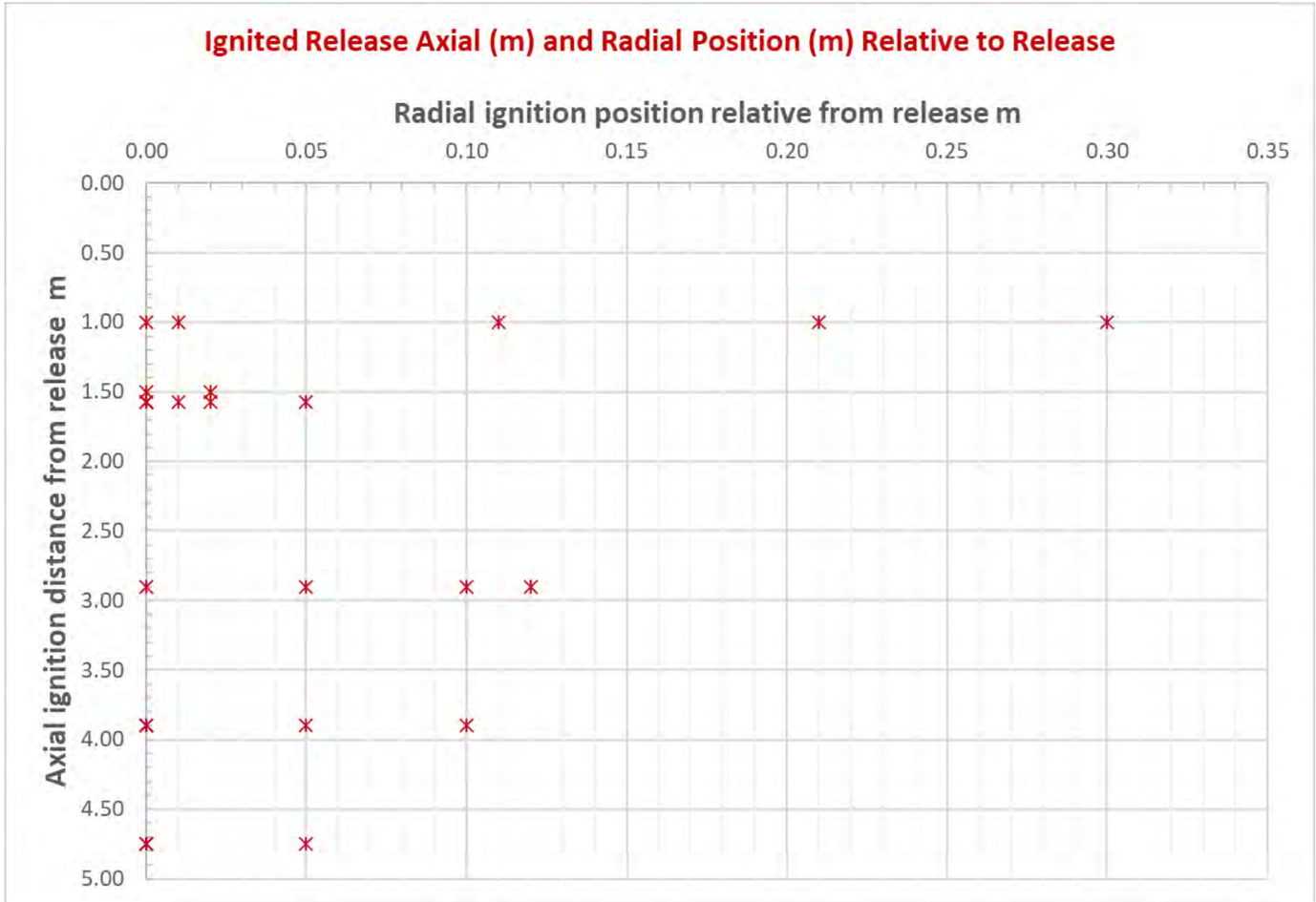


Figure 07: Ignited release locations relative to release location (m)

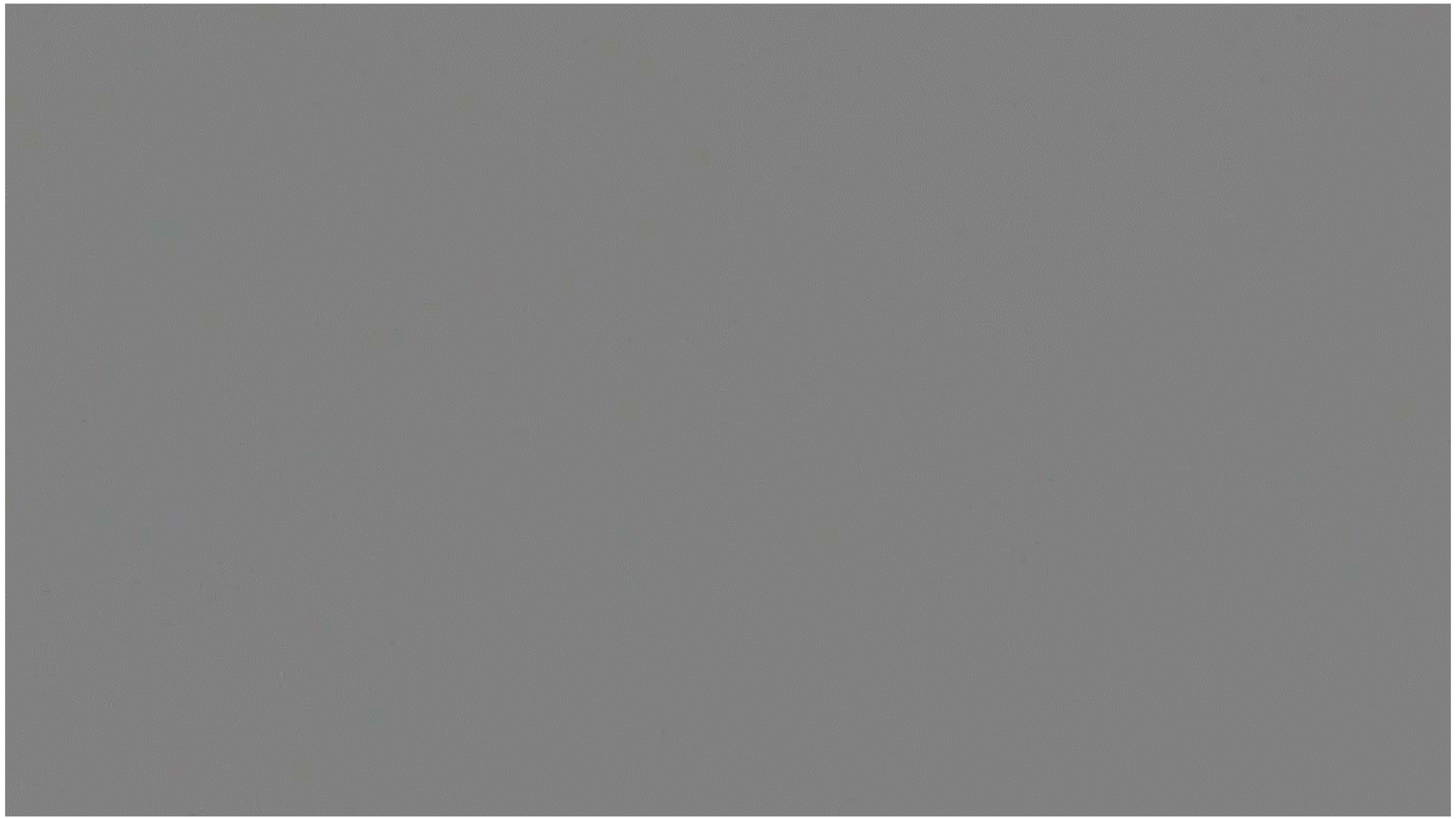
1m Axial Igniter Distance

1.5m Axial Igniter Distance

2.9m Axial Igniter Distance

3.9m Axial Igniter Distance

4.75m Axial Igniter Distance



Ignition videos and flame behaviour

- A change in flame behaviour was observed with increasing axial igniter distance

- With increasing axial distance between the release and ignition point, the flash fires became less vigorous, and a much slower flame growth was observed. The flash fire was of short duration, partially due to the cessation of the mist jet release.

Mist visualisation

Figure 49 left: Test 1 – 1.0 m axially from release (pressure 4.19 bar g)

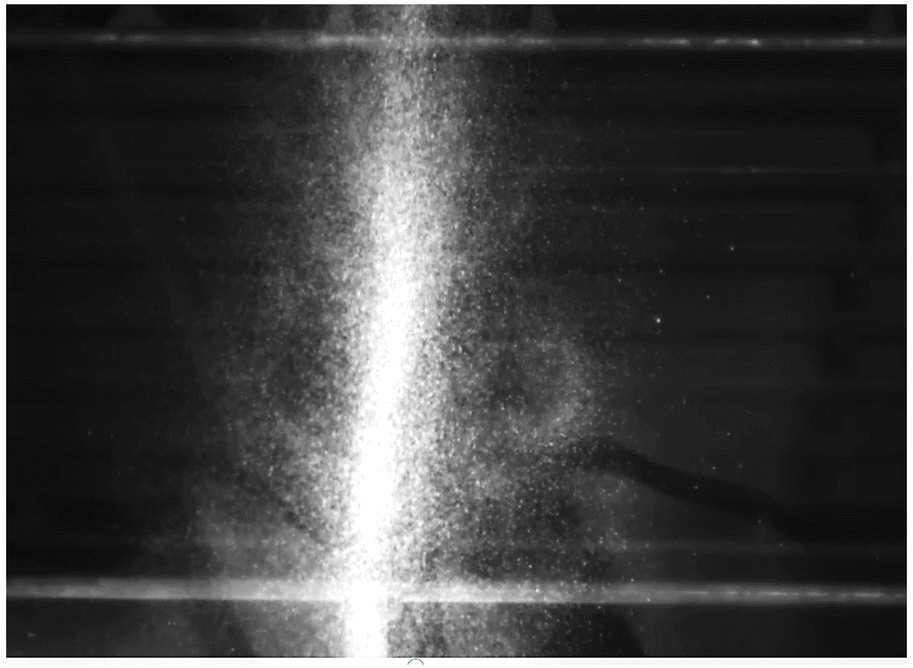


Figure 52: Test 3 shot b – 1.35 m from release (pressure 5.13 bar g)

Figure 59: test 9 shot b – 4.75 from release (pressure 4.90 bar g) * highlights are lights through the black background from lighting

CONCLUSIONS

Conclusions

- The diesel mist jet was found to be ignitable at a test pressure of 5 bar g with a 1J spark igniter.
- The mist was ignitable for at least 4.75 meters
- The mist was only ignitable a short distance away from the centreline of the jet.
- The mist composition when studied with the use of CCTV and high-speed imagery does not form a uniform spray.

Conclusions

- There was a significant change in the flame behaviour of the ignited mist with increasing axial distance between the release and ignition point.

- This work shows that the zoning for diesel fuels requires consideration. It may not be unreasonable for an elevated diesel transfer line in a facility to be zoned to include a larger distance below the line rather than simply a uniform radius around it.

Conclusions

- Further work could be undertaken to improve our understanding of the consequence of mist ignitions where a sustained but initially unignited release leads to mist accumulation.
- The effect of reduced ignition energy could also be investigated to further understand the likelihood of ignition of the mist with commonly encountered ignition energies.

ACKNOWLEDGMENTS

Acknowledgements

- Thank you to HSE,
- Mark Royal
- Dr Richard Bettis and Dr Simon Gant

  Office for Nuclear Regulation(ONR),

  Energy Institute (EI),

  Shell
- Thank you to GTRC – Anthony Giles

- Thank you to Keith Tremble Pictured on the Left
- Thank you to Andrew Tooke Pictured on the Right

For more information: Louise.osullivan@hse.gov.uk

RESEARCH AND GUIDANCE FROM HSE

Thank you

For more information: Louise.osullivan@hse.gov.uk
: Richard.bettis@hse.gov.uk